BELLCOMM, INC.
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B70 01047

SUBJECT: Lunar Rover Wheel Performance Tests - Case 320

DATE: January 27, 1970

FROM: J. D. Richey

MEMORANDUM FOR FILE

INTRODUCTION

Performance tests of two candidate LRV wheels are being conducted at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. The results of the tests will be used to select and, if necessary, improve the wheel for LRV use.

The mobility performance of an off-the-road vehicle is dependent upon the conditions of the soil in which it is run and cannot be reliably predicted theoretically. Therefore, it is mandatory to test wheels to be used on off-the-road vehicles in the actual soil environment to determine wheel performance.

The soft soil mobility performance of a wheel is characterized by its drawbar pull, power efficiency and slip. The data to determine these parameters, are obtained by moving a wheel under a constant vertical load across a soil test section at a known linear speed while driving the wheel at a known angular velocity. The relative relationship between angular velocity and linear velocity is the wheel slippage.

The writer, along with Messrs. A. P. Victors of the AC Electronics-Defense Research Laboratory and D. Schuring of Cornell Aeronautical Laboratory witnessed, on December 17 and 18, two tests of the candidate wheel which utilizes an unpressurized tire consisting of a layer of Armalon sandwiched between two layers of wire mesh. The tire is approximately 9.00-14 in size. The two tests were conducted with the same wheel loading but the soil conditions were different with each test. The other candidate wheel is the same size as the sandwich wheel but the tire consists of a single wire mesh; it was tested later. The test program at WES requires that each of the two wheels be tested at three load conditions and four soil conditions.

TEST APPARATUS AND PROCEDURE

The wheel to be tested was mounted on a carriage suspended from rails above a soil bin. A test consisted of moving the test wheel across the test section of soil, decreasing the linear speed (v) of the test wheel from a given initial velocity to zero, while

maintaining the angular speed (ω) constant with the applied torque (M). For these tests the slip (S) ranged from -10% to +100%. The carriage maintained a constant vertical load (w) on the test wheel throughout the test. Measurements were made of drawbar pull (P) throughout the test. Figure 1 is a sketch of the test apparatus.

The soil used in the tests, Yuma sand, was thoroughly mixed to achieve uniform conditions throughout the test section. The soil properties were measured to ascertain the soil conditions and to assure uniformity in the test section.

PERFORMANCE PARAMETERS

Throughout the tests, the significant measured parameters were recorded and also routed to a facility computer, which computed slip, pull number, [the ratio of drawbar pull to the load on the wheel P/W], and other significant test results as indicated in Figure 1. These data are used to evaluate the general performance characteristics of the tested wheel. In particular, the pull number, the power efficiency of the wheel, $Pv/M\omega$, and the slip provide a quantitative measure of the wheel's capability for negotiating slopes, towing a load, accelerating, etc.

Data obtained from this type of test can be used to plot pull number as a function of slip. The curve in Figure 2 shows the general relationship between pull number and slip for the type wheels and soil which were used in the tests. It is desirable for a wheel to have a large pull number, low slip, and high power efficiency.

TEST RESULTS

For the first of the two tests witnessed, the soil was loose and had a moisture content of 1.4%, maximum P/W was .38. In the second test, the sand was packed to medium density, and had a moisture content of 1.4%; the maximum P/W was 0.54. This latter result compared favorably with maximum P/W ratios of 0.55 and 0.51 achieved by a pneumatic tire and the Bendix LRV wheel respectively in tests conducted several months earlier with similar soil conditions. The pneumatic tire and Bendix wheel were considered by WES personnel to have pull numbers satisfactory for use on an LRV.

OBSERVATIONS

The tests at WES are conducted in a careful, methodic manner. The data obtained should be accurate and reliable and

most useful in evaluating candidate LRV wheels. Based on operational experience obtained from the use of Armalon in the CM crew couches the writer suggested to Mr. A. P. Victors that the Armalon may pose a durability problem. Mr. Victors was not aware of the CM experience, and indicated that he will closely monitor the performance of Armalon throughout the durability tests.

CURRENT STATUS

Preliminary results of the tests conducted at WES indicate that the maximum P/W of the double wire mesh-Armalon sandwich wheel is approximately .54. During the last test of the sandwich wheel the Armalon developed a circumferential tear approximately one foot long near the center of the tread. The cause of the tear is unknown. However, Armalon has been discarded as inadequate for use as a liner in the LRV wheels. Nomex will be used as the liner in the durability test. Preliminary data from WES indicates that the single wire, mesh wheel picked up a large amount of sand. The effect of this has not been assessed.

In traction tests at General Motors, Cleveland, Ohio, the single mesh wire wheel achieved a maximum P/W of .56. The sandwich wheel has been sent to GM for further traction testing. On completion of the traction tests at GM the wheels will be shipped to the AC Electronics-Defense Research Laboratories at Santa Barbara, Calif. where they will be tested for durability.

J. D. Richey

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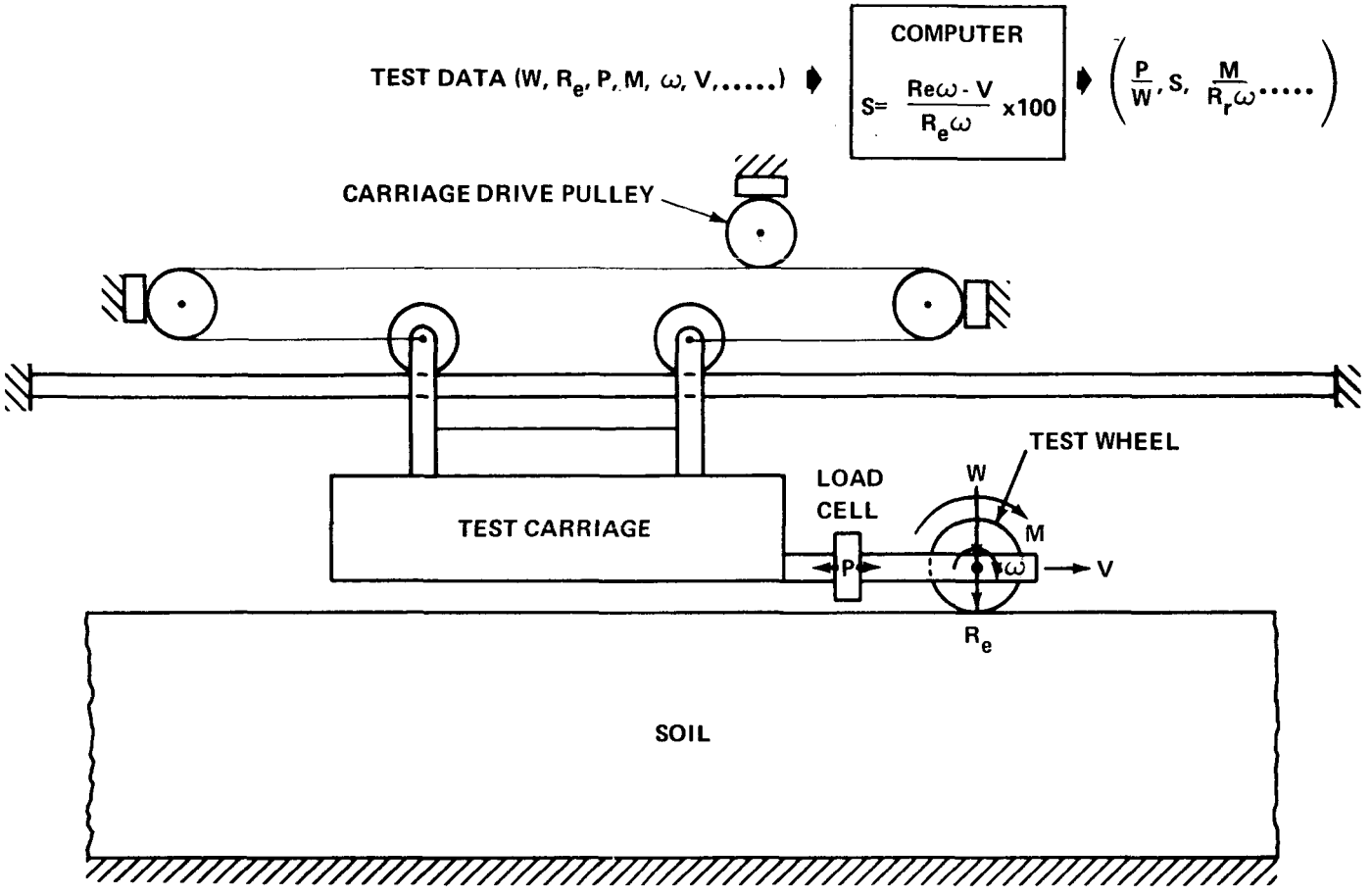
Attachments
Figures 1 & 2



R_e = EFFECTIVE RADIUS OF WHEEL

W = LOAD ON WHEEL

V = CARRIAGE SPEED

ω = ANGULAR VELOCITY OF TEST WHEEL

S = SLIP

P = DRAWBAR PULL

M = TORQUE AT WHEEL AXLE

FIGURE 1 - WHEEL PERFORMANCE TESTING

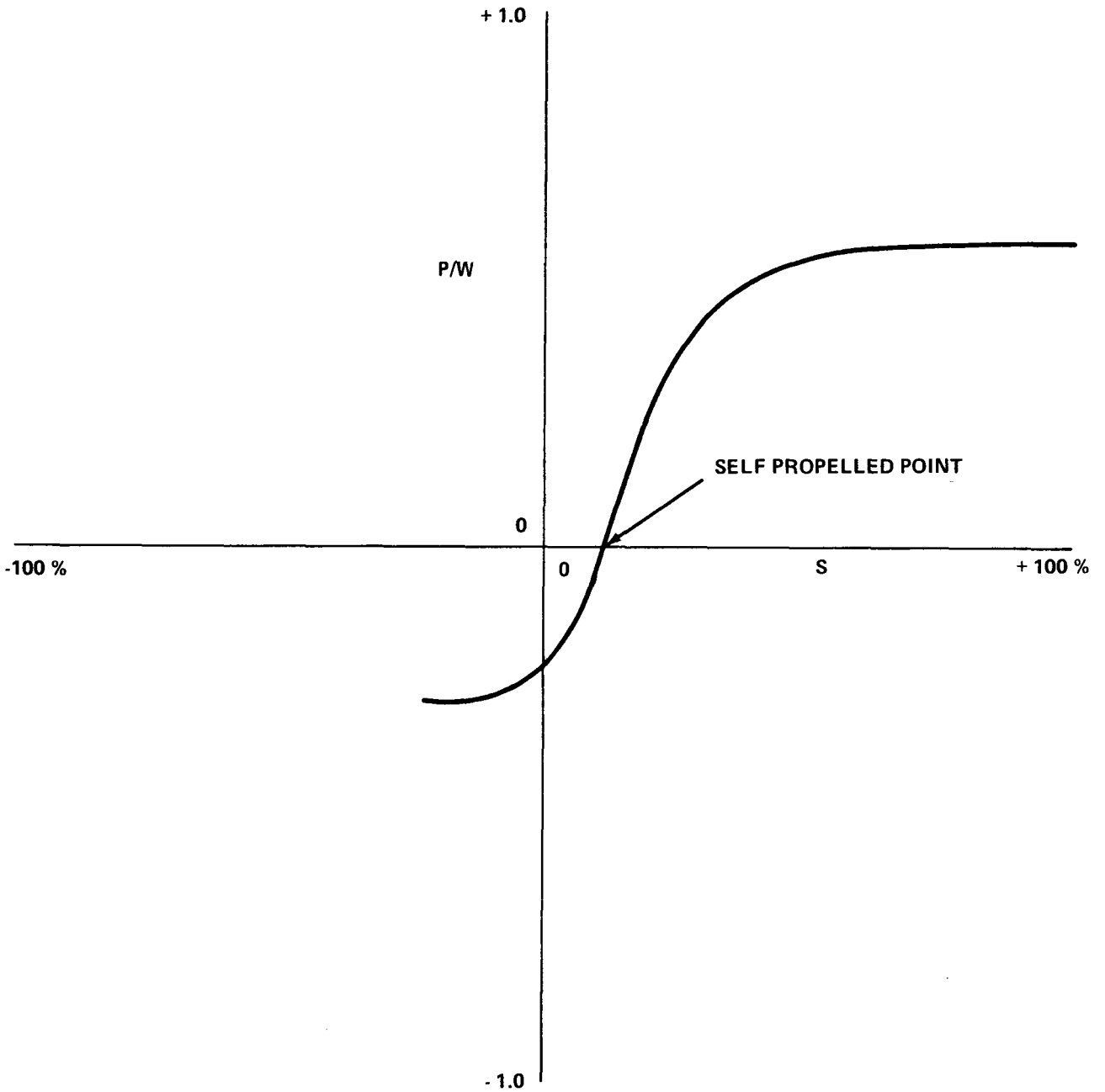


FIGURE 2 - TYPICAL PERFORMANCE CURVE FOR LRV WHEEL IN SAND

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